# The IEA Annex 20 Two-Dimensional Benchmark Test for CFD Predictions

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model of MARIA. In so doing, experimental tests, using pollution by tracer gas, are carried out in the actual building for each existing ventilation system and for different pollution scenarios. Then, simulations are done by considering weather and indoor hygrometric and thermal conditions measured during the experiments. Finally, comparisons are made between the experimental and the numerical results in terms of pollution level indoors.

**Results**

The analysis is focused on pollutant spread within the dwelling. The results show similar dynamics in relevance to the tracer gas concentrations resulting from the model and the experiments. However, the accuracy of the results (from the airflow model) is quite different depending on both the ventilation system and the location of the pollutant source. Besides, the high levels of concentrations provided by the model are an indication that a good modelling of MARIA requires a more precise knowledge of airflow paths and connections, such as the façade air leakage and air leakage between rooms. Then, the parametric study performed to illustrate this assumption shows good relevance.

**Conclusions**

The validated multizone airflow model is coupled with a thermal model for analysing the performances of ventilation strategies towards indoor air quality, energy demand and comfort. The whole model is therefore intended to be quite useful in solving combined heat and mass transfer problems in buildings.

**R4-TS52-OP03**

## THE IEA ANNEX 20 TWO-DIMENSIONAL BENCHMARK TEST FOR CFD PREDICTIONS

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**Introduction**

The IEA Annex 20 two-dimensional test case was selected by the participants of the Annex 20 work in 1990 as a benchmark 1. Figure 1 shows the dimensions of the geometry.
The air distribution in the benchmark corresponds to the situation in a room with a slot inlet and isothermal flow. The dimensions and flow conditions are the following: L/H = 3.0, h/H = 0.056 and Re = 5000, where L, H, h, Re are length, height, slot height and Reynolds number, respectively. Velocities are measured in a model with W/H = 1.0 2, and streaklines are photographed in a model with W/H = 4.7 3.

**Application of the Benchmark**

About 50 different applications of the benchmark (made between 1989 and now) can be found on the web page www.cfd-benchmarks.com. The different CFD predictions cover aspects as: grid dependence, numerical schemes, different source codes, different turbulence models, RANS or LES, different length scales in a supply opening, study of local emission and airborne chemical reactions.
The comparisons with measurements in the benchmark are therefore supplied by the information which can be obtained by the comparison with other predictions. Results and conclusions The flow in the benchmark has been considered to be two-dimensional and steady. This study shows that three-dimensional unsteady flow could exist. LES predictions indicate an asymmetrical probability density function at the floor at x/H = 1.0 with a probability of both negative and positive velocities. Measurements in rooms with L/H >= 4.0 and W/H = 4.7 do also show unsteady flow at the floor for 0 < x/H < 1.0.
Two-dimensional steady state predictions with different turbulence models indicate a large difference in this region as shown in figure 2.

This study also shows the simulation of three-dimensional isothermal unsteady flow which expresses any differences between this type of flow and two-dimensional steady state flow.

Literature

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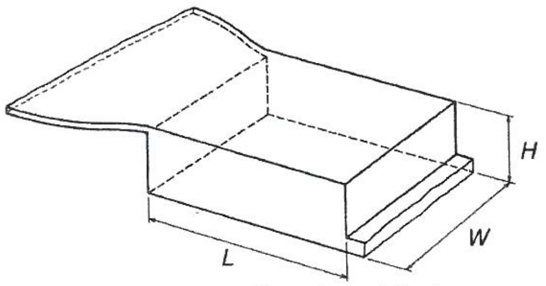
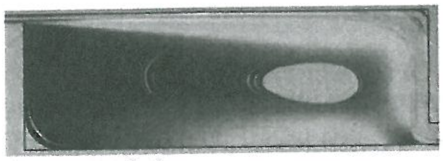



*The two-dimensional benchmark test*



$k$- $\varepsilon$ model

$k$-$\omega$ SST model

*Two dimensional isothermal and steady state simulation of the Annex 20 2D benchmark test.*

**R4-TS52-OP04**

## DEVELOPMENT OF ENERGY CONSUMPTION CALCULATION PROGRAM FOR INDIRECT ADIABATIC COOLING EQUIPMENT

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### Introduction

The energy consumption in buildings in last twenty years has increased enormously. Ventilation, air conditioning and heating contribute significant part of total energy consumption in the building. The energy efficiency of mentioned systems significantly influences the operating costs for building. One of solutions how to decrease energy consumption for air conditioning systems is by replacing traditionally and widely used systems with more energy efficient systems. Indirect adiabatic cooling is energy efficient air-conditioning system that utilizes the free cooling effect. However the performance is significantly influenced by weather conditions – outside temperature and humidity level in specific geographical locations therefore it is important that the potential energy savings can be easily measured in the system selection process. This paper reports on simulation program development for calculations of energy consumption for indirect adiabatic cooling equipment used for a project in any geographical location.

### Methods

The energy consumption calculation program is developed using Matlab Simulink simulation program with graphical user interface and with plotting functions of results. The simulation model consists of logical modules - average climatological year for specific geographical location; heat and humidity balance in premises; adiabatic cooled air heat exchanger; water heat exchangers; compressor cooling plant with power modulation; and fan with frequency converter. The output readings are - air temperature and humidity parameters after air heat exchanger and condenser; water temperature after water heat exchanger from adiabatic cooling and water temperature after heat exchanger from evaporator. Using the output results, the electrical energy consumption in kW is calculated.

### Results

The developed simulation program calculates the total and breakdown by component yearly electrical energy consumption of indirect adiabatic cooling equipment. The energy consumption calculation program also has the outputs of energy total and detail cost calculation. As well as the payback period if compared to traditionally used equivalent cooling capacity air-cooled chiller. The graphic reports deliver overview on calculated cooling capacity, supply and return air temperature and energy costs.

### Conclusions

The developed simulation program can be used to find energy consumption of indirect adiabatic cooling equipment in any project in different climate conditions by inputting the climate data of specific country. The next research step will be empirical validation of the accuracy of the energy consumption